CHAPTER 1

INTRODUCTION

1.1 GENERAL

Elastic fabrics and their garments have instant response and return to their original size and shape due to physical exertion by any organ of the human body. These garments are mainly used in sports activities such as cycling, swimming and athletics etc, as they improve the sportsmen performance by offering least resistance during garment stretch and by enhancing the power by quick recovery of the fabric dimensions, because of the usage of elastane in these garments. A simple and ordinary body movement expands the skin by about 10 to 50% (as shown in Figure 1.1). Therefore, the strenuous movements of active sports will require least resistance from garment and instant recovery. Good elastic fabric will make a good sportswear. The degree and direction of elasticity determines the end uses of stretch garments (Voyce et al. 2005). Fabric elastic recovery is as important as stretching (Voyce et al. 2005 and Guillaume et al. 2006).

Figure 1.1 Body skin stretch at different parts
Evaluation of fabric elastic characteristics can be assessed in two methods: namely, static elastic recovery (Arnold and Hazel 1946 and Hazel et al. 1965) and dynamic elastic recovery (Ching et al. 2004). Static elastic recovery of the fabrics mainly helps to analyse the fabric dimensional stability, whereas, that of the dynamic elastic recovery of the fabrics helps to analyze the instant garment response to body movements.

1.2 DYNAMIC ELASTIC BEHAVIOUR OF ELASTIC FABRIC

Analysis of dynamic elastic behaviour is an objective evaluation of the stretch and recovery performance of the elastic fabrics or tight fit garments. The analysis of this dynamics will help to engineer new products for improving the stamina, speed and power of the sportsmen, as one particular type of garment doesn’t serve the purpose of all kinds of sports events.

![Stress strain behaviour of identical elastic fabric](image)

**Figure 1.2 Stress strain behaviour of identical elastic fabric**

Stress strain behaviour of identical elastic fabric is shown in Figure 1.2. Loading and unloading behaviour of the fabric is almost curvilinear, which is normally called as elastic deformation. This fabric is
perfectly suitable for elastic sportswear where it requires stamina and power. But, most of the textile fabrics are non-linear in nature (viscoelastic deformation), which will produce hysteresis loop (Dunja and Vili 2008). Higher the hysteresis area, the higher will be the energy loss, i.e. lower the fabric stress and strain recovery. The elastic fabrics should have higher elastic recovery with lower energy loss so that the wearer will get the additional benefit such as improved stamina and power to perform sports activity.

![Hysteresis Loop](image)

(a) Stress nodes (S1 – S4)  
(b) Strain nodes (E1 – E4)

**Figure 1.3  Stress and strain behaviour of fabrics – stress and strain nodes**

Hypothetical stress strain behaviour of elastic textile fabric is shown in Figure 1.3. There are some stress nodes from S1 to S4 in the fabric for applied extension (Figure 1.3(a)), when the fabric is subjected to four cyclic movements. The garments produced from these kinds of fabrics will generate air space between body and garment for each body movement. This will create a problem to maintain body temperature and energy during any activity especially in the field of sports. Similarly, there are some strain nodes from E1 to E4 in Figure 1.3(b). The garments produced from these kinds of fabrics will change their position for every movement of the body since they are tight-fit wear. These kinds of fabrics will give skin strain (or) skin irritation. These two types of stress strain behaviour of the fabrics are
uncommon. So, these two hypothetical behaviours of the fabrics are not considered in this study.

The recovery behaviour of the fabric or garment is important to enhance the power of the sports person involved in strenuous sports activity. In general, elastic textile material will give minimum work energy loss which can be calculated by assessing dynamic work recovery (Figure 1.4).

![Dynamic Work Recovery Diagram](image)

**Figure 1.4 Dynamic work recovery**

Dynamic Work Recovery (DWR) of the fabric is calculated by the equation (1.1).

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\text{Dynamic work recovery} \% = \frac{\text{Area under the unloading curve}}{\text{Area under the loading curve}} \times 100 \quad (1.1)
\]

In order to explain the dynamic elastic behavior of fabrics, two hypothetical examples are shown in Figures 1.5 (a) and (b). The elastic hysteresis of two fabrics A and B are shown in Figure 1.5 (a). Fabric A has higher dynamic work recovery value than Fabric B. Higher the DWR of fabric, the higher the garment response to human body skin movement. This leads to improved retention of stamina, speed and power during sports.
activities. When DWR value of the fabric is lower, resistance offered by the garment for the body movements are higher and it leads to higher metabolic loss of the body, which results in discomfort for sportsmen during their activity.

(a) Fabric A and B has unequal DWR      (b) Fabric C and D has equal DWR

**Figure 1.5  Elastic hysteresis of hypothetical fabrics**

The elastic hysteresis (Masaru Matsuo et al. 2009) of second set of hypothetical fabrics C and D are shown in Figure 1.5 (b). Even though there is a marked change in the hysteresis behavior, still they will show the same DWR values, since, Fabric C has high stress value with high energy loss. Similarly, Fabric D has lower stress with less energy loss. If that is the case, it is necessary to analyse the fabric stress value with respect to specific extension. In order to select a right fabric for tight fit sports garments, it is necessary to study the fabric DWR and stress value to analyse the garment response objectively.

It is understood that the stamina and power of the sports person will improve by reducing the energy loss of the fabric. So, the assessment of fabric energy loss is important for analyzing the performance of the tight fit sportswear. This research work mainly deals with the study of dynamic elastic
behaviour such as fabric DWR and stress at specific extension of elastic fabrics made from spandex back plated cotton single jersey knitted fabrics (Bayazit 2003), in order to develop a new product in the field of sportswear manufacturing. In order to study the dynamic elastic behaviour of the elastic knitted fabrics, the following objectives were arrived.

1.3 SCOPE OF THE PRESENT STUDY

The aim of this research work is to study the effect of material variables, machine variables and processing treatments on dynamic elastic behaviour of cotton / spandex knitted fabrics, in order to analyse the performance of the fabric and their garments for sports persons who require stamina and power during their strenuous sports activity.

The thesis is divided into eleven chapters. Chapter 1 introduces the subject and discusses the need for undertaking the study. Chapter 2 gives an extensive literature survey on the subject. This literature review provides a background and guidance for the entire study.

Chapter 3 describes the materials and methods used for preparing the knitted fabric samples required for the study. Further, the testing procedures adopted for the analysis are also described.

Further chapters describe the effect of material variables on dynamic elastic behaviour of cotton / spandex knitted fabric. Chapter 4 compares the dynamic elastic behaviour of cotton and cotton / spandex knitted fabrics. Chapter 5 compares the dynamic elastic behaviour of spandex back plated cotton knitted fabric and spandex core cotton spun yarn knitted fabric. Chapter 6 compares the dynamic elastic behaviour of cotton / spandex knitted fabrics made from (i) ring and rotor yarns and (ii) ring and compact yarns.
Chapter 7 describes the effect of machine variables on dynamic elastic behavior of cotton / spandex knitted fabric. The objectives under this chapter are to study the effect of spandex tension, spandex linear density and cotton loop length on dynamic elastic behaviour of cotton / spandex knitted fabrics.

The following chapters deal with the effect of processing treatments on dynamic elastic behavior of cotton / spandex knitted fabrics. Chapter 8 deals with the effect of heat setting and compacting temperatures on dynamic elastic behaviour of cotton / spandex knitted fabrics. Chapter 9 describes the laundering effect on dynamic elastic behaviour of cotton and cotton / spandex knitted fabrics.

Chapter 10 describes the design and development of a pressure sensing device for analysing pressure comfort on elastic garments for tight fit sportswear.

Finally, summary of the entire study and the various conclusions drawn from the studies are presented in Chapter 11.